

Packaging Concerns and Techniques for Large Devices

Challenges for Complex Electronics

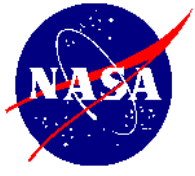
**Components for Military and Space Electronics
(CMSE)**

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FPGAs- A Sampling of Challenges

Can we “qualify” without breaking the bank?

New Silicon

- 90nm CMOS
- new materials

New Connectors

- higher-speed, lower noise
- serial/parallel

New Board Material

- thermal coefficients
- material interfaces

New Architectures

- new interconnects
- new power distribution
- new frequencies



New Workmanship

- inspection, lead free
- stacking, double-sided
- signal integrity

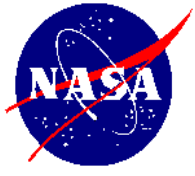
New Design Flows/Tools

- programming algorithms, application
- design rules, tools, simulation, layout
- hard/soft IP instantiation

New Package

- Inspection
- Lead free

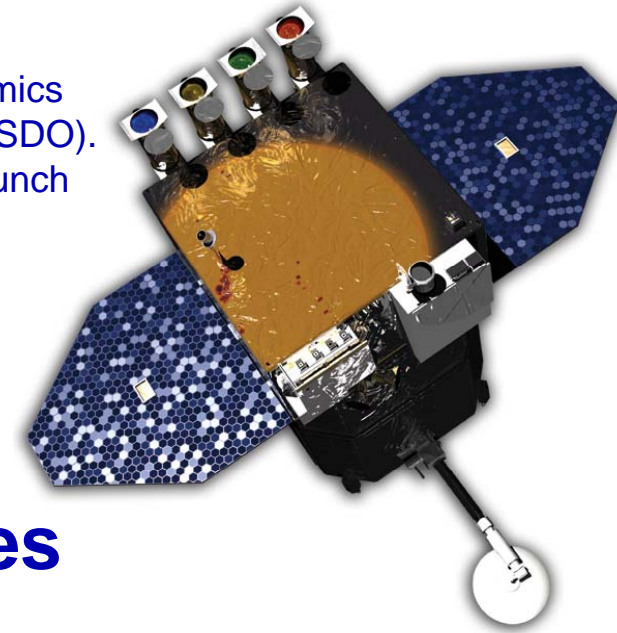
Where we were
©2006

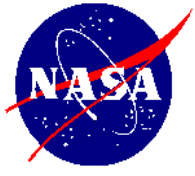


Overview

- **Packaging Challenges**
- **Packaging Options**
- **Components of All Packages**
- **Commercial, Non-hermetic Packages**
- **Space Challenges to Packages**
- **A Non-hermetic, Complex Package for Space**
- **Hermeticity, Why Space Users Like It**
- **Non-hermetic, Complex Package Variations**
- **Class X**
- **Summary**

Solar Dynamics
Observatory (SDO).
Awaiting Launch



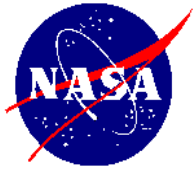


Packaging Challenges

- **I/O s, increasing number, decreasing pitch**
- **Heat Dissipation, especially in space**
- **Manufacturability**
- **Materials**
- **Mechanical**
- **Installation**
- **Testability**
- **Inspectability**
- **Space Environment**
- **RoHS (Pb-free)**

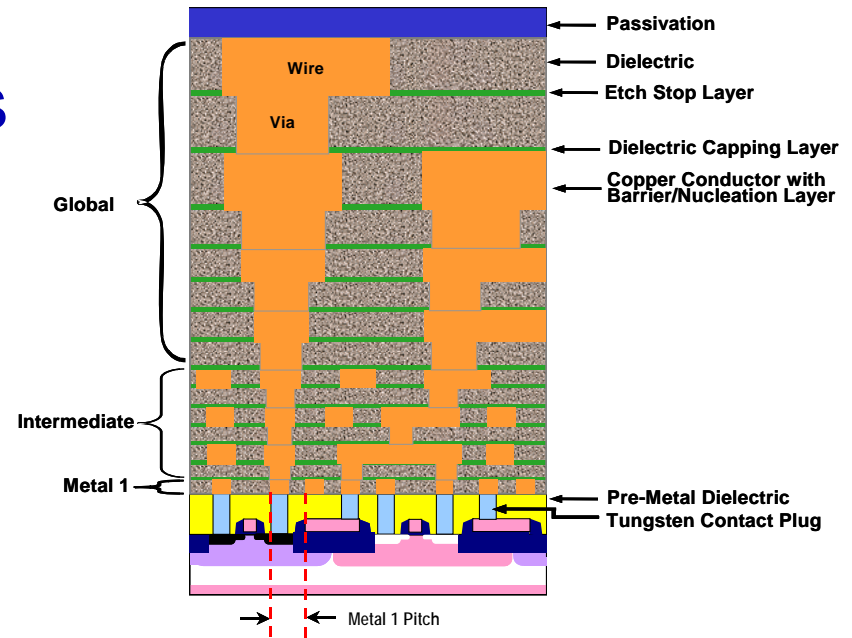


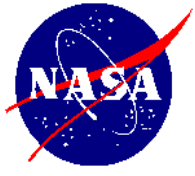
Lunar Reconnaissance Orbiter (LRO), Built at GSFC,
Launched with LCROSS, June 18,2009



Package Options – Hermetic?

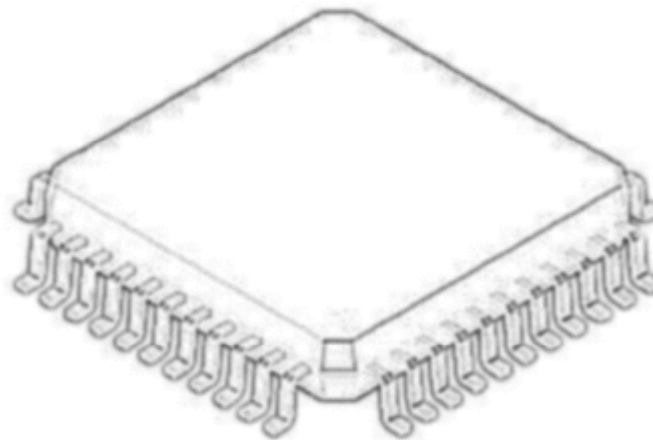
- Driven by consumer products
 - Low cost
 - High volume
 - Rapid turnover
 - “Green”
 - Minimized size
- Once, hermetic options existed for most package types
 - Now, few hermetic options for latest package technologies
 - Development of new hermetic options unattractive
 - » Very high NRE
 - » Very high technical difficulty
 - » Very low volume
 - » Demanding customers

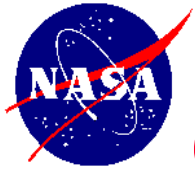




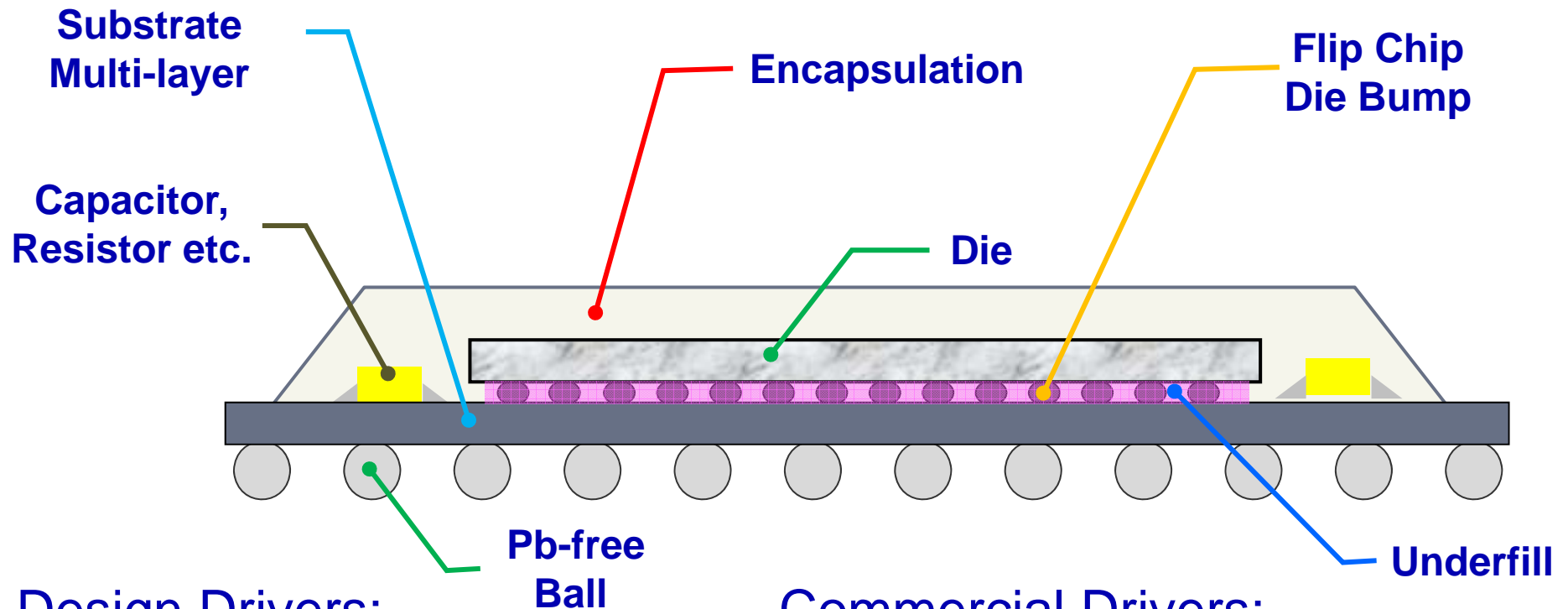
The “General” Package

- Typically, packages consist of the same basic features but achieve them in many ways:
 - Functional elements - active die, passives etc.
 - Interconnects between elements (2 or more elements)
 - A substrate
 - Interconnects to the external I/O of the package
 - A protective package
 - Interconnects to the next higher level of assembly





Commercial, Non-hermetic Package (PBGA)

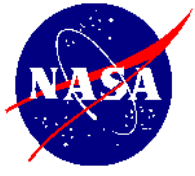


Design Drivers:

- High I/O count
- Large die
- Environmental protection
- Performance/Speed
- Ancillary parts

Commercial Drivers:

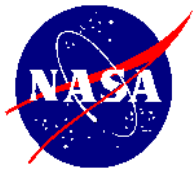
- Low cost
- High volume
- Limited life
- Automated installation
- Compact



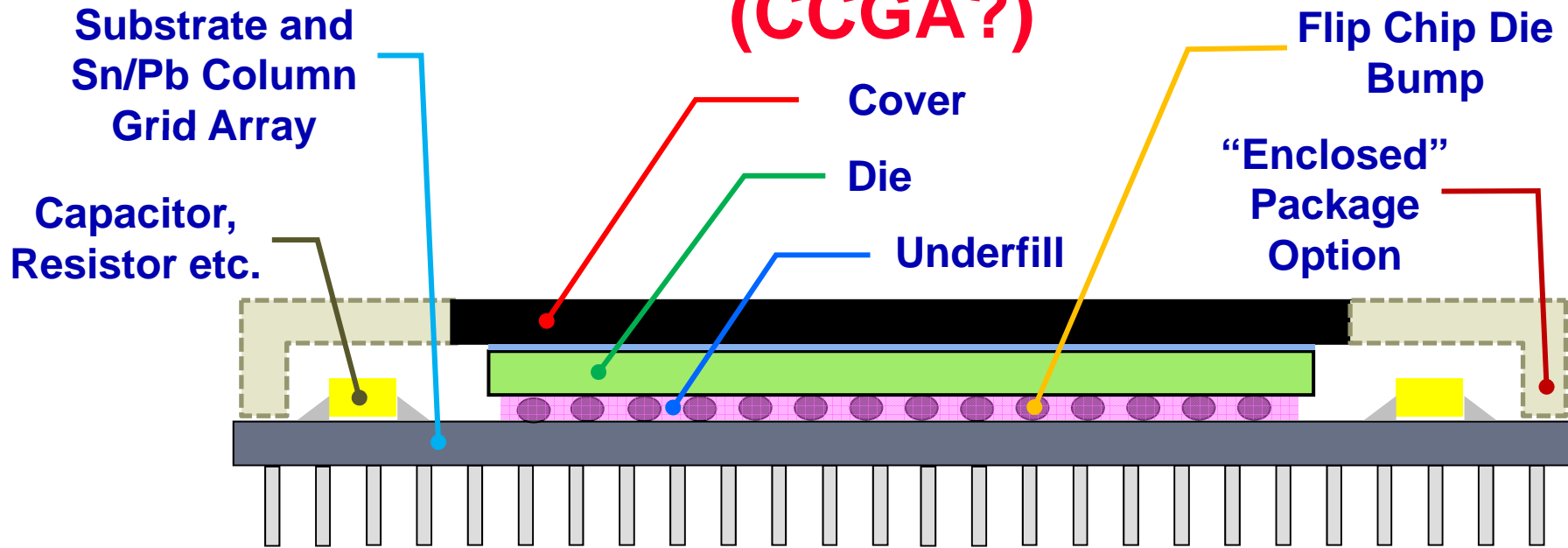
Space Challenges for Complex Non-hermetic Packages

- **Vacuum:**
 - Outgassing, offgassing, property deterioration
- **Foreign Object Debris (FOD)**
 - From the package threat to the system, or a threat to the package
- **Shock and vibration**
 - During launch, deployments and operation
- **Thermal cycling**
 - Usually small range; high number of cycles in Low Earth Orbit (LEO)
- **Thermal management**
 - Only conduction and radiation transfer heat
- **Thousands of interconnects**
 - Opportunities for opens, intermittent - possibly latent
- **Low volume assembly**
 - Limited automation, lots of rework
- **Long life**
 - Costs for space are high, make the most of the investment
- **Novel hardware**
 - Lots of “one offs”
- **Rigorous test and inspection**
 - To try to find the latent threats to reliability

**ONE
STRIKE AND
YOU'RE OUT!**



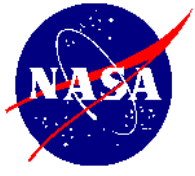
Non-hermetic Package, With "Space" Features (CCGA?)



Space Challenge

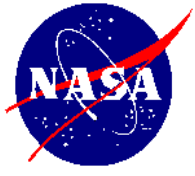
Some Defenses

Space Challenge	Some Defenses
Vacuum	Low out/off-gassing materials. Ceramics vs polymers.
Shock and vibration	Compliant / robust interconnects - wire bonds, solder balls, columns, conductive polymer
Thermal cycling	Compliant/robust interconnects, matched thermal expansion coefficients
Thermal management	Heat spreader in the lid and/or substrate, thermally conductive materials
Thousands of interconnects	Process control, planarity, solderability, substrate design
Low volume assembly	Remains a challenge
Long life	Good design, materials, parts and process control
Novel hardware	Test, test, test
Rigorous test and inspection	Testability and inspectability will always be challenges



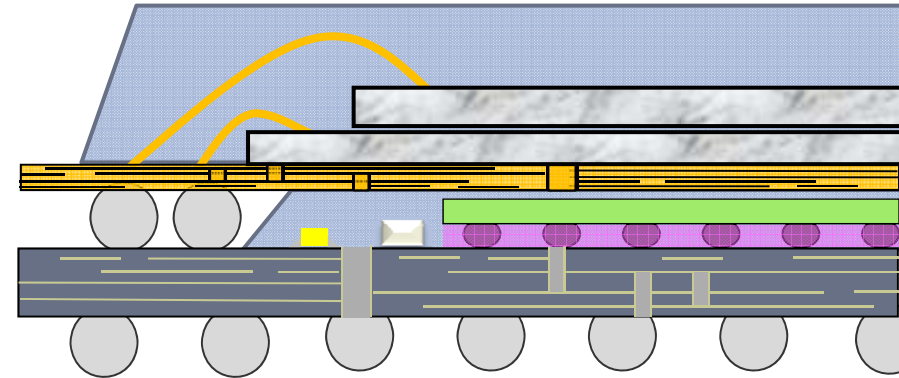
Hermeticity

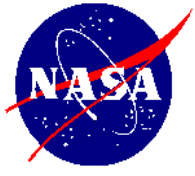
- NASA prefers hermetic packages for critical applications
- Hermeticity is measureable, assuring package integrity
- Only 3 tests provide assurance for hermetic package integrity:
 - Hermeticity – nothing bad can get in
 - Residual or Internal gas analysis – nothing bad is inside
 - Particle Impact Noise Detection – no FOD inside
- **NON-HERMETIC PACKAGE INTEGRITY IS HARD TO ASSESS - NO 3 BASIC TESTS**



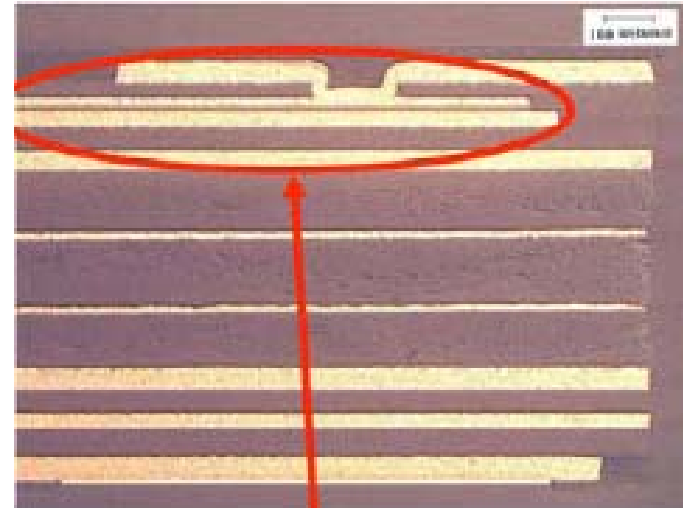
Non-hermetic Package Variations

- Current and future package options mix and match elements in almost infinite combinations
- Elements include:
 - Wire bonds
 - Ball interconnects
 - Solder joints
 - Conductive epoxies
 - Vias
 - Multi-layer substrates
 - Multiple chips, active and passive (hybrid?)
 - Stacking of components
 - Embedded actives and passives
 - Polymers
 - Ceramics
 - Enclosures/encapsulants
 - Thermal control features

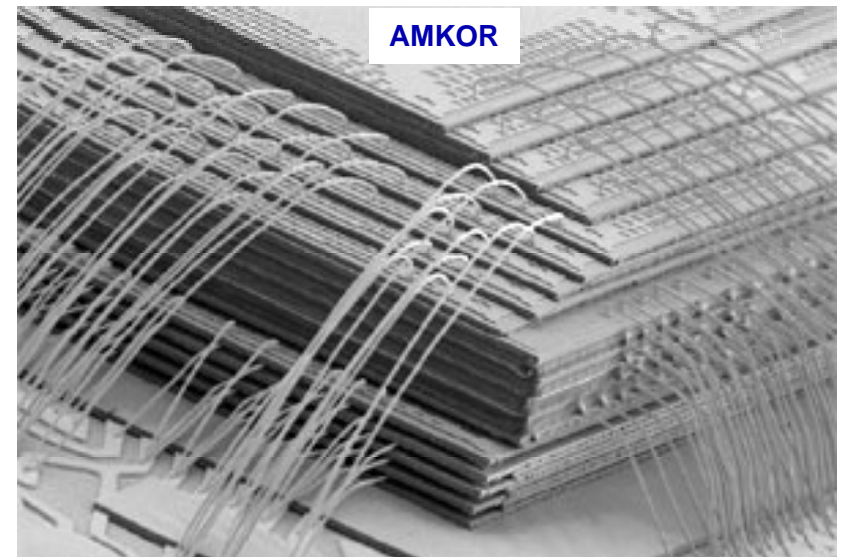
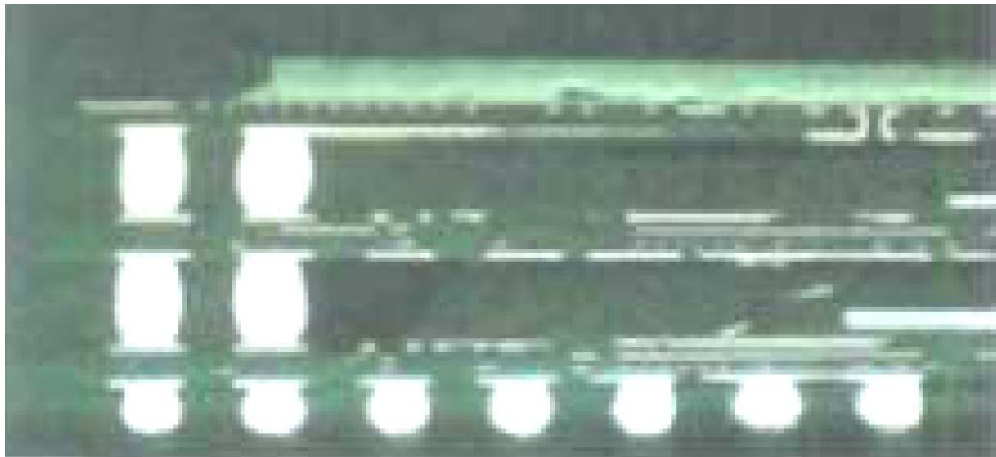




Some Large Device Package Options

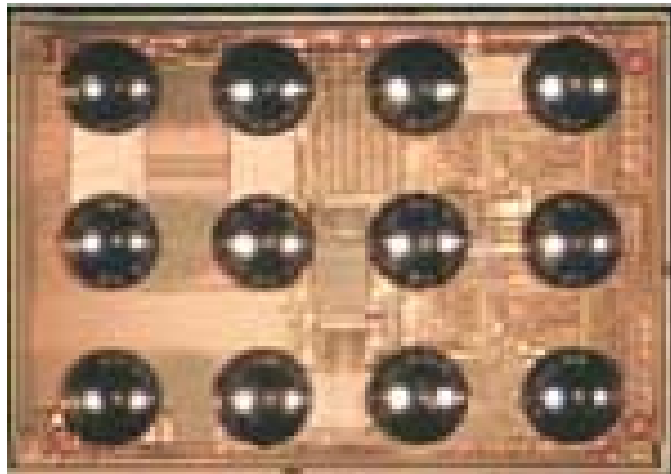


Embedded Capacitor





Some Large Device Package Options



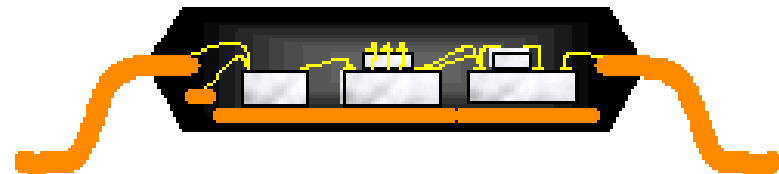
2 Die Stack



3 Die Stack



**6 Die Multi-Chip Module
Stacked Die ePad LQFP**

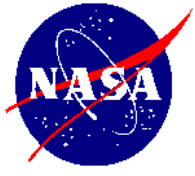


From Amkor's Website <http://www.amkor.com/go/packaging>

Why MIL Spec. for Space ?

- **Space users like MIL spec. parts because:**
 - There are technical “rules” that apply equally to all suppliers
 - Qualification to recognized requirements
 - Visibility of change control
 - Required tests and inspections reduce or eliminate the need for the space user to do post-procurement tests
 - Transparent government process for reacting to performance issues
 - Space level participation provides an opportunity to do continuous improvement of the MIL supply chain for Class S (space grade) microelectronics

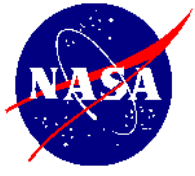
They Work!



MIL-PRF-38535, Class Y

- **Proposed new class for M38535, monolithic microcircuits**
- **Class Y will be for Space level non-hermetic**
- **Class V will be defined as hermetic only**
- **Addition to Appendix B, “Space Application”**
- **Package-specific “package integrity” test requirements proposed by manufacturer, approved by DSCC and government space**
- **The Package Integrity Test Plan must address:**
 - **Potential materials degradation**
 - **Interconnect reliability**
 - **Thermal management**
 - **Resistance to processing stresses**
 - **Thermo-mechanical stresses**
- **G12 Task Group established 01/13/01**



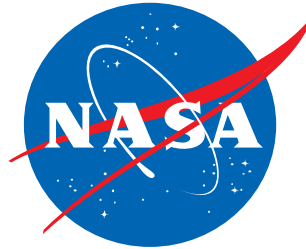


Summary

- NASA is going to have to accept the use of non-hermetic packages for complex devices
- There are a large number of packaging options available
- Space application subjects the packages to stresses that they were probably not designed for (vacuum for instance)
- NASA has to find a way of having assurance in the integrity of the packages
- There are manufacturers interested in qualifying non-hermetic packages to MIL-PRF-38535 Class V
- Government space users are agreed that Class V should be for hermetic packages only
- NASA is working on a new Class for non-hermetic packages for M38535 Appendix B, "Class Y"
- Testing for package integrity will be required but can be package specific as described by a Package Integrity Test Plan
- The plan is developed by the manufacturer and approved by DSCC and government space



NASA Electronic Parts and Packaging (NEPP) Program



<http://nepp.nasa.gov>